DG 24: Current problems and challenges in distance teaching and learning

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Aims and focus

DG 24 (which was attended by almost fourty participants) met three times to discuss current general researches and particular experiences in the field of distance teaching and learning. The group focused on the new powerful means and techniques that mitigate the problem of distance in the processes of teaching and learning as well as on perspectives of developing the software products in the field. Particular focus was paid to the following issues:

- Common principles and differences in the various modern concepts of distance teaching and learning (DTL).
- New technologies to be used in DTL in the nearest future.
- Successes and difficulties in present DTL researches and experiences.

The first session began with a round table discussion, with each participant describing his/her background and interest in the field. It turned out that there was a very broad spectrum of interests covering all sectors of the mathematics curriculum. Debra Woods then gave a lucid account of her experience of the distance learning programme based on the software *Mathematica* at the University of Illinois at Urbana-Champaign. As one of the first initiatives to use computer algebra technology this generated much further discussion.

The second and third sessions concentrated on three themes

- How to organize content and manage the process of education?
- How to organize remote on-line interaction between student and teacher?
- How to organize a full-scale mathematics course run through the internet?

The main thrust of all the discussion concerned technological questions.

One of the most popular topics turned out to be learning and teaching geometry via the internet. Contemporary e-technologies provide great potential in this area, and present challenging opportunities to modern high school education (both theory and practice). Three topics related to this geometrical theme were discussed in depth:

- the application of existing e-educational standards to planning, creating, packaging and delivering geometry e-courses
- the organization of distributed storage of e-learning materials to enable on-request search, and customizable assembly of e-courses by remote internet access
- the provision of an “e-environment” that fosters and maintains distributed collaboration among remote students and tutors when studying geometry.

The first topic concentrates on applying the so-called SCORM (Sharable Courseware Object Reference Model) standard (together with other related e-learning standards) to the requirements of e-learning design. To comply with SCORM, any e-learning system will consist of a Learning Management System (LMS) processing learning e-courses (the content). A student acquires knowledge when interacting with the content under the supervision of the LMS, so that the latter plays the role of a tutor in the learning process. The SCORM-compliance guarantees inter-operability between any LMS and any e-course regardless of the underlying technology. SCORM compliance is an important requirement of LMSs. Unfortunately a present-day LMS often looks like rather a "mechanical piano". It answers the question "what to learn?", by defining content, but says next to nothing concerning the "how to teach?" question (which is a much more complicated and intellectually challenging one). New approaches to this problem were discussed.

The second topic concerns principal questions which are traditional for distributed systems and, as a consequence, important in distance learning too: how should registration and storage of e-learning courses be organized in order to provide efficient search and fast structural access to learning materials? Many important aspects of e-learning depend on such distributed organization of the e-learning content. For instance; can one find the desired learning content using a set of indirect descriptions – perhaps formulated in terms of learning metadata? Or is it possible to dynamically create an on-demand e-course whose structure is influenced by individual e-learning history of an individual student?

The last topic focuses on support of the distributed collaborative "learning by doing" process. As a specific example, a student can learn by solving a geometrical problem being driven by remote tutor, who manages the same pictorial constructions and demonstrates correct approaches to obtaining the result. Such processes imply not only distributed resources, but also a built in functionality of interaction in both synchronous and asynchronous modes. Unfortunately, current SCORM compliant systems (and other existing commercial e-learning systems that the authors are aware of) provide only partial solutions in distributed environments, mainly because there is no effective standardized support of the interaction capability. So, in summary, the prospect of standardizing interactivity and building it into existing standards for distributed systems is attractive and potentially very powerful. However to date the results are sparse and fragmentary and this is certainly an area that will repay future investigation.

There were many contributors to the debate, several of whom showed prototypical systems that have been used in a distributed context. Some particularly notable examples were as follows.

Luiz Carlos Guimarães (Brazil) presented two DGS (Dynamic Geometry Software) computer programs currently being developed by group in the Laboratório de Matemática Aplicada of the Federal University of Rio de Janeiro.

Tabulæ is a program to facilitate dynamic plane geometry, which has, at the time of writing, been a year in development. Entirely written in Java, in its current version it displays facilities similar to those available in other DGS systems such as Sketchpad and Cabri. However there is a greatly increased capability for communication and interaction between remote users. However the system still lacks a few basic features such as a proper scientific calculator interface, and a macro facility.

Mangaba is a tool for solid geometry. Its main features include building primitives, transformations and resources available for visualisation, object editing, import/export of code and the feature of construction sharing. It could be used in elementary and secondary schools. Once again there is a facility for communication and remote interaction.

TT2K. Valery Krivtsov (Russia) presented the geometry e-learning environment TT2K developed by the Department of Distributed Computing of Institute for System Analysis of Russian Academy of Sciences. The TT2K is a distributed NG e-learning system possessing advanced functionality which can be accessed either locally or by the internet. It can

- treat any SCORM-compliant learning course
- analyse a current student's past achievement and dynamically form an individual route through the learning course
- create mini-courses on user demand
- store and retrieve individual results of learning.

The TT2K prototype at present works in the context of school geometry (but is extensible). It handles an electronic version of "Geometry 7", a Russian school textbook by Igor Sharygin. In order to foster the learning of geometry TT2K provides advanced functionality for supporting live geometrical sketching and real-time collaboration between student and teacher (via the internet). Such synchronous communication is important, for instance, when teaching teenagers. Many students cannot keep their interests and activities if response time exceeds some minimal value. Synchronous mode systems allow response times that are effectively zero. Collaboration between learners is also of great importance and valuable learning seems impossible without it. The computer can assist a teacher, but is not a substitute for him/her.

Educational applications and design aspects of a generic and heuristic step-by-step problem solver

The discussion was not confined solely to geometry. Bernhard Zgraggen (Switzerland) presented educational applications and design aspects of a generic and heuristic step-by-step problem solver. Providing step-by-step solutions to mathematical problems through the internet plays an important economic and didactic role in distance education. A project at the Distance University of Applied Sciences of Switzerland deals with the development and deployment of programs interactively generating detailed and dynamic step-by-step solutions to typical problems in higher mathematical education using *Mathematica*.

Already developed are software modules for advanced mathematical topics like computation of limits, determination of extremal values, analysis of functions, series approximation, computation of differentials, solving linear equation systems, linear optimization and Lagrange optimization problems. These have been tested among students and tutors in a distributed context. The software modules can be accessed and controlled via the internet (www.webmath.ch)

AiM (Assessment in Mathematics)

The final session had an extremely important discussion of techniques for assessment of mathematics by computer. Chris Sangwin (United Kingdom) presented a system, widely used at the University of Birmingham) that deals with assessment in mathematics. (Further details at http://web.mat.bham.ac.uk/C.J.Sangwin/aim/index.html). Interesting aspects of this system include the generation of random versions of questions that are:

- well-posed in a mathematical sense
- fair, when used in assessment
- progress through a scheme of different cases, not just "as random as mathematically possible" and the generation of worked solutions. (These cases can be either from randomly generated problems, or from questions asked by students.)

This work is novel in that a computer algebra system is used to support open-ended questions, eg "give me an example of a function with the following properties". The possibilities are far greater than with conventional multiple-choice tests.

At the end of the group's final session it was agreed that a platform should be maintained on the internet for ongoing discussions concerning distance education.

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They are happy to be contacted for further information on the work of this DG.